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# A Study on Subsidence Problem in Kusma Area, Parbat District.

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**Abstract**

The Kusma terrace is about 250 m high above the Kaligandaki River bed. It is composed of highly cemented conglomerate of unsorted subangular to rounded pebble to boulder sized rock fragments of metasandstone, limestone, quartzite, gneiss and phyllite. Owing to calcareous cementing matrix conglomerate is maturely karstified with formation of prominent features of tower karst, pinnacles, solution chimneys and fissures. Solution channels are filled up by slope wash deposit of recent age. The subsurface flow through these channels scours the unconsolidated slope wash deposit and ultimately cause land subsidence and sink holes.

## Introduction

Kusma Area has long been facing a perpetual problem of land subsidence which was not so much known to the outsiders. Sink holes just suddenly occur in anywhere of the Kusma area. There were a few incidences of collapses of walls of the houses. Local people were used to live with this phenomena.

## Physiography

Kusma is the district headquarter of Parbat District located at latitude 28°13'30" and longitude 83° 41'. It is a noselike terrace southwestward extended from the Khurkot-Durlung mountain. It is bounded by Kaligandaki River in the west and Modi Khola in the east. The elevation of Kusma terrace is about 250m from the Kaligandaki River. The terrace wall is mostly vertical. There are prominent scree deposits with some slide material resting all along the vertical wall of the terrace. Normally the scree deposit is thick at the base of the terrace.

Kusma terrace is at lower elevation than Balewa terrace where the airport is located. It extends from Chamarka to Chuwa. The Hatiya terrace located at the other side of Kusma across the Modi Khola appears to be the same age as the Kusma terrace. The terrace has been deeply incised by the seasonal creeks coming from the mountain side separating the terrace.

## Conglomerate Deposit

Conglomerate deposit of the area is a superconcentrated stream flow and debris flow deposit brought from the Higher Himalaya which once filled the whole Kaligandaki valley (Kansakar et. al., 1982). It is well cemented rounded to subangular pebbles and cobbles with some occasional big boulders of various rock fragments of limestone, banded gneiss and quartzite. Cementing material is calcareous. It is normally unsorted and inhomogeneous. Only at some place, bedded layers are observed. It is thickly unconformably lying over the phyllite bedrock which is sometime cropping out in the river bed of Kaligandaki and Modi Khola. The thickness of conglomerates seems to be as thick as 250m, which means the valley was once filled up to this level.

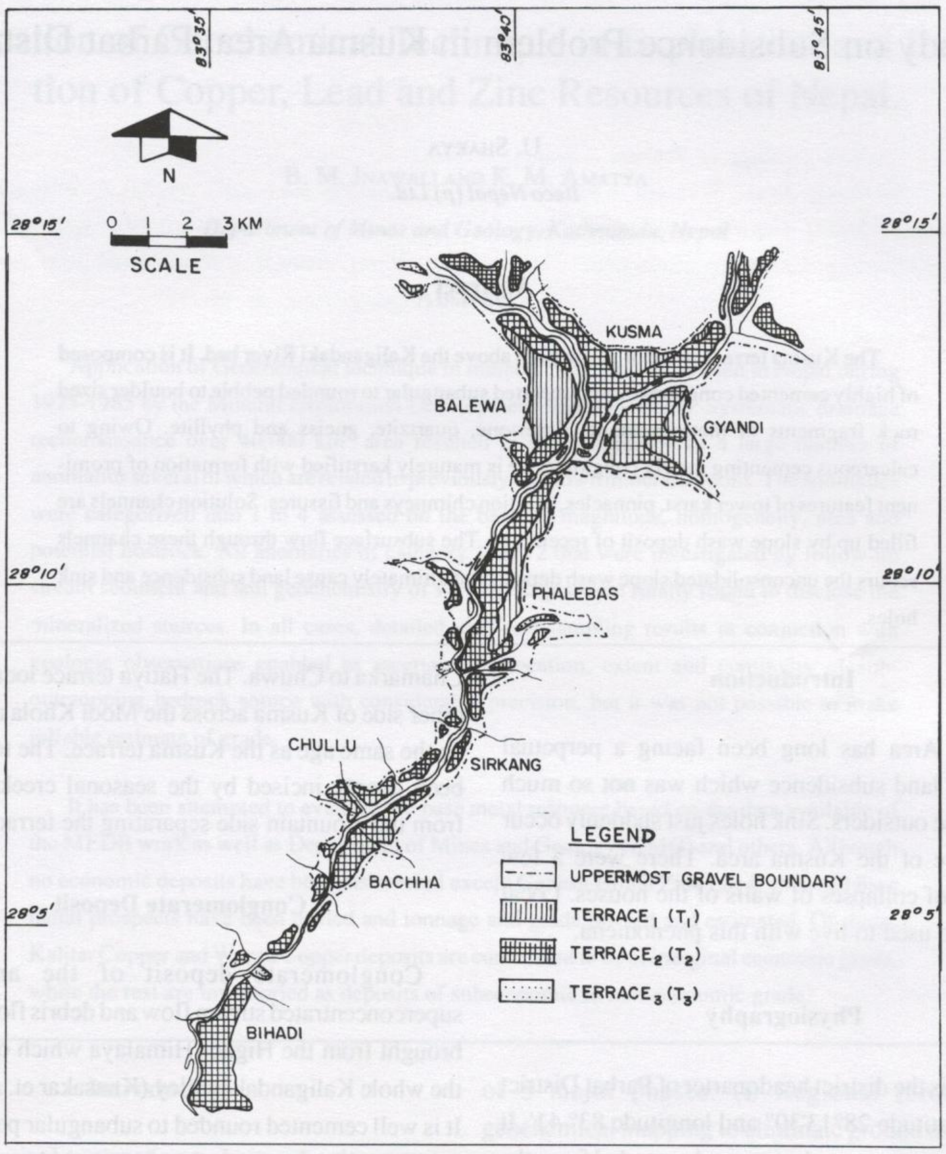


Fig. 1. Terraces of Kaligandaki Valley (After Kansakar et. al., 1982)

## Karstification

Karstification has been maturely developed in the conglomerate deposit of the Kusma terrace. As the conglomerate is composed of inhomogeneous rock fragments of various rock types, karstification is also inhomogeneous and mostly controlled by regional lineaments, joints and distribution of rock fragments. The terrace surface exhibits doline karst landscape with residual karst hills (Plates 1 and 2). The dolines (sinkholes) of different sizes have been observed. These are distributed sparsely in the compound of Chief District Office, Kusma Hospital and Jail area (Plate 3). The most significant karst features are tower karst and pinnacles with solution chimneys, vertical shaft and solution fissures which are distributed in a complex labyrinth form. These towers and pinnacles with open fissures are clearly exposed at the knick of the terrace. Their surface exhibits various solution sculpture of smoothened runnel (rinnenkarren) and spongework of solution groovings and pittings. The depth of fissures seem more than 10m and less than 15m.

Plate 1. Residual karst hills and karst landscape in Kusma terrace.

The residual karst hills are raising out of the terrace surface as in the cone shaped mound in isolated form. These karst hills are nothing but group of tower karst and pinnacles of conglomerate with the same solution chimneys and fissures but filled up with slope wash deposit.

A cave known as Gupteswor Mahadev cave at Kusma is a single conduit type cave almost parallel to creek lying just over it. The cave is about 2-3m wide and 3-6m high formed by indistinct joint. It is extended for about 400-500m length with some minor bends and some wider rooms. It has rough and irregular pitted surface in the wall and crown. Some crownfall has been observed which has been recemented by travertine. Stalagmite and stalactite are not well developed but there are drippings of solution at some places with prominent pendants.

## Slope Wash Deposits

Slope wash deposits are referred to such deposits as talus, colluvial and scree deposits brought from the upper mountain slope to the downslope commonly by means of heavy rainfall action. It has filled all the narrow and deep openings like solution chimneys and fissures. Such filling materials are the youngest deposit and varies in composition from place to place. It is unconsolidated sediment and normally a light yellow to orange coloured, non plastic to low plastic sandy silt. At the mountain side, it is coarser and contains pebbles, cobbles and sandy silt matrix with some occasional boulders. It is more finer sediment towards the Kaligandaki River valley side. Its depositional slope has maintained a smooth change of slope from the mountain slope to the terrace plane.

Plate 2. Doline formation karst towers and pinnacle.

## Subsidence Mechanism

In order to describe the subsidence mechanism, it must be envisaged that Kusma terrace is made up of well cemented conglomerate with deep karstified pinnacles, towers and solution channels filled up with

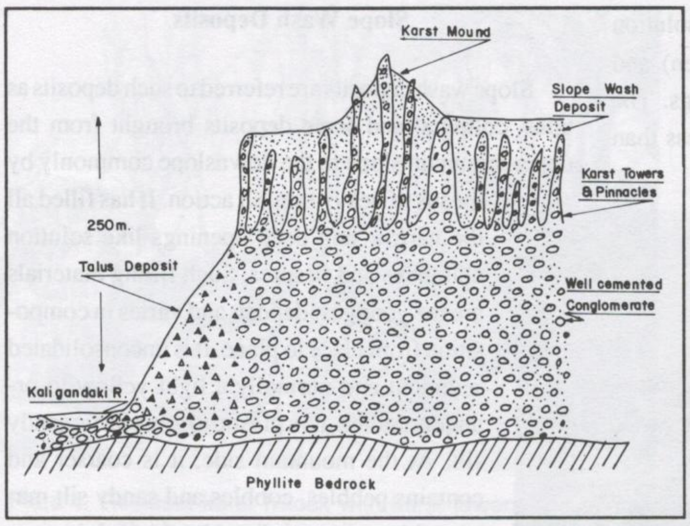

Fig. 2 Schematic geological cross-section of Kusma Terrace.

unconsolidated slope-wash deposit (Fig. 2). Those filled-up materials are relatively porous and allow surface water to percolate through them. The percolated water starts to flow along the karstic solution channels. It sooner or later comes out from the terrace


Plate 3. Sinkhole in Kusma Jail area.

through the terrace wall boundary as karst springs scouring the underneath filled materials. Thus it creates the caverns or voids underneath forming soil arch which stopes in upward direction to the surface. It ultimately collapses abruptly due to its own weight which is classified as collapse dolines (sinkholes) (Fig. 3). On the other hand underneath soil piping can also cause gradual settling of ground if the mantle soil does not have sufficient cohesiveness to maintain a mechanically stable soil arch above the developing void. It is at first manifested by gentle sag detectable only by the occurrence of circular puddles after rainstorms. Then the ground continues to settle down further with circular shear cracks and subsequently widens at variable speeds over a period of hours, days or weeks. Thus such sinkholes are subsidence dolines (Fig.4)

## Remedial Measures

Whenever subsidence is observed, it has been the general practice to fill up the sink hole with the boulder mixed soil. It seems that in most of the filling cases either the hole is not completely filled up or filling material is not well compacted. For an example the filling of such sink holes at the Hospital and at the Jail area is not effective. It is found to be still sinking and causing the cracks in the wall of the adjacent buildings. Thus some remedial measures are proposed in order to overcome such sinkhole problems.

### *Filling up the sink holes*

Filling up of the sink holes with the boulder mixed soil should be carried out properly with due considerations of subsidence reasons.

a. Dig out up to the bottom of the sink holes. See whether there is any other flow channels. In case

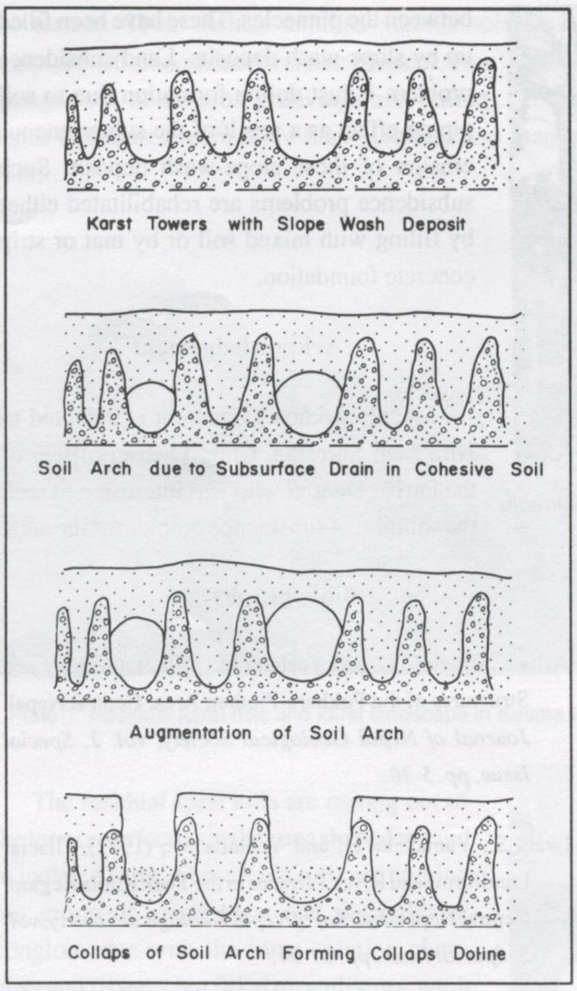


Fig. 3 Schematic presentation of mechanism of collapse doline.

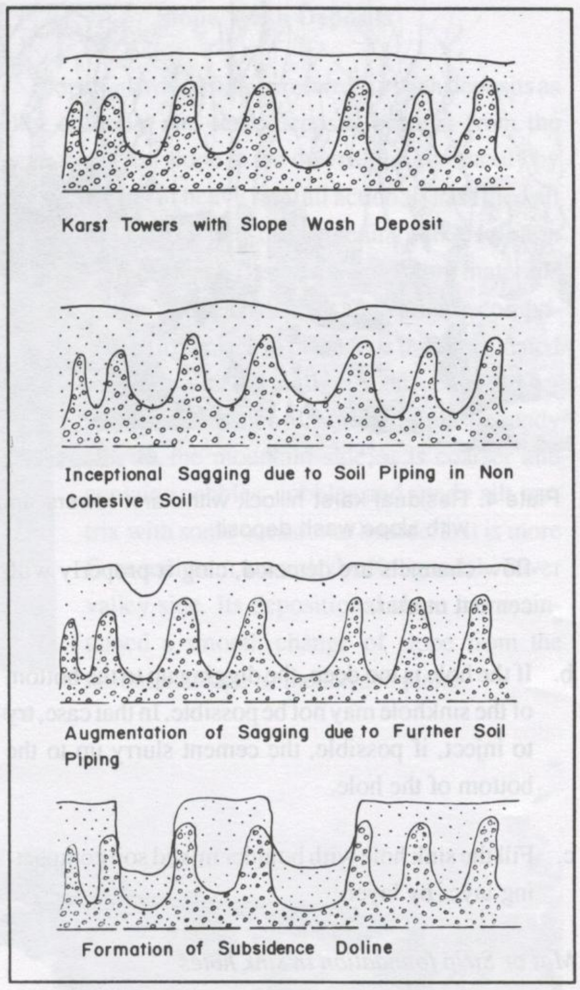


Fig. 4 Schematic presentation of mechanism of subsidence doline.

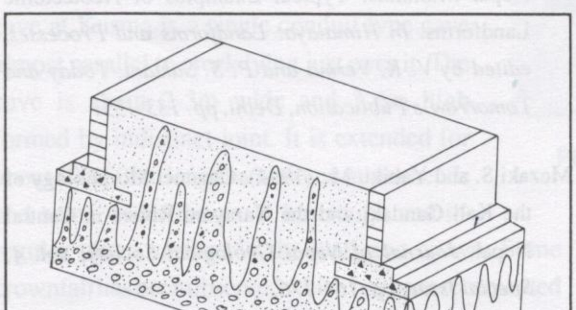

Fig. 5 Sketch of reinforced concrete strip foundation.

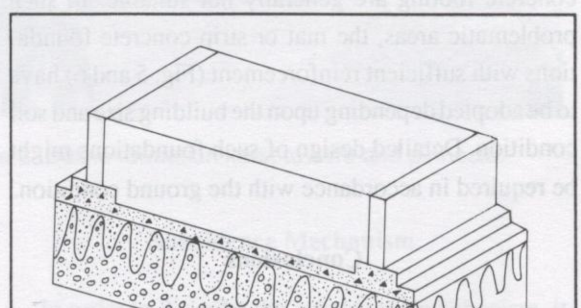

Fig. 6 Sketch of reinforced concrete mat foundation.

Plate 4. Residual karst hillock with karst towers and pinnacle with slope wash deposit.

flow channels are detected, clog it properly with cement mortar.

b. If the hole is too deep, the digging up to the bottom of the sinkhole may not be possible. In that case, try to inject, if possible, the cement slurry up to the bottom of the hole.

c. Fill the sink hole with boulder mixed soil compacting layer by layer.

*Mat or Strip foundation in sink holes*

In the area of sink hole problems, the most common type of foundation like load bearing wall or isolated concrete footing are generally not suitable. In such problematic areas, the mat or strip concrete foundations with sufficient reinforcement (Fig. 5 and 6) have to be adopted depending upon the building size and soil condition. Detailed design of such foundations might be required in accordance with the ground condition.

## Conclusions

Kusma terrace is made up of well-cemented thick conglomerates. The conglomerate deposits have been karstified forming a system of pinnacles and a labyrinth pattern of deep solution chimneys and fissures between the pinnacles. These have been filled up by slope-wash deposits. Land subsidence problem is just doline formation due to soil piping effect as a result of the subterraneous erosion of these slope-wash deposit. Such subsidence problems are rehabilitated either by filling with mixed soil or by mat or strip concrete foundation.

## Acknowledgement

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